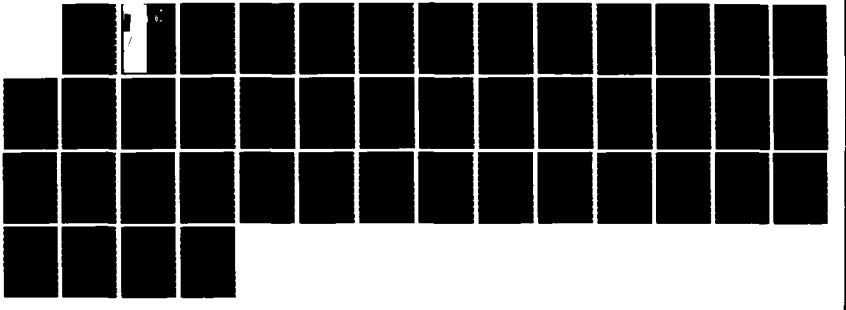
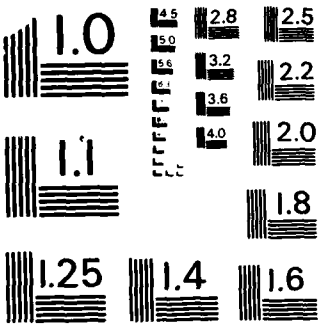
AD-A169 803 GOAL ORIENTED VEHICLE EVALUATION SUPPORT SYSTEM (GOVESS) FUNCTIONAL SPECI..(U) STEVENS INST OF TECH HOBOKEN NJ DAVIDSON LAB M P JURKAT ET AL. OCT 85 1/1

UNCLASSIFIED SIT-DL-85-9-2533 DADE07-82-C-4075 F/G 5/8 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS - 1963 - A

AD-A169 803

(3)

DTIC
ELECTE
S JUL 14 1986
D

DAVIDSON LABORATORY

REPORT NUMBER SIT-DL-85-9-2533

October 1985

GOAL ORIENTED VEHICLE EVALUATION SUPPORT SYSTEM (GOVESS) -- FUNCTIONAL SPECIFICATION

BY:

M. Peter Jurkat
and
Peter M. Brady, Jr.

Prepared for:

U.S. Army Tank-Automotive Command
Warren, MI 48397-5000

Under:

Contract DAAE07-82-C-4075
(DL Project 431/5060)

APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION IS UNLIMITED.

STEVENS INSTITUTE OF TECHNOLOGY

CASTLE POINT STATION
HOBOKEN, NEW JERSEY 07030

R-2533

86 7 11 016

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION / AVAILABILITY OF REPORT Approved for Public Release; Distribution is Unlimited.
2b DECLASSIFICATION / DOWNGRADING SCHEDULE	
4 PERFORMING ORGANIZATION REPORT NUMBER(S) SIT-DL-85-9-2533	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a NAME OF PERFORMING ORGANIZATION Davidson Laboratory 6b OFFICE SYMBOL (If applicable)	7a NAME OF MONITORING ORGANIZATION U. S. Army Tank-Automotive Command
6c ADDRESS (City, State, and ZIP Code) Castle Point Station Hoboken, NJ 07030	7b ADDRESS (City, State, and ZIP Code) ATTN: AMSTA-RSS Warren, MI 48397-5000
8a NAME OF FUNDING / SPONSORING ORGANIZATION U.S. Army TACOM 8b OFFICE SYMBOL (If applicable)	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER DAAE07-82-C-4075
8c ADDRESS (City, State, and ZIP Code) Warren, MI 48397-5000	10 SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO / PROJECT NO / TASK NO / WORK UNIT ACCESSION NO

11 TITLE (Include Security Classification)
GOAL ORIENTED VEHICLE EVALUATION SUPPORT SYSTEM (GOVESS) FUNCTIONAL SPECIFICATION

12 PERSONAL AUTHOR(S)
M. Peter Jurkat and Peter M. Brady, Jr.

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Final	FROM July '82 TO July '85	October 1985	-46-

16 SUPPLEMENTARY NOTATION

17 COSATI CODES		
FIELD	GROUP	SUB-GROUP
05	08	

18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Expert Systems, Military Vehicles, Mission Performance, ~~Mobility, Survivability~~, Vehicle Performance.

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

Specification, to a functional level, have been developed for a Goal Oriented Vehicle Evaluation Support System (GOVESS) which, when implemented, will support a user in the performance of vehicle ride, obstacle negotiation, mobility, impact survivability, and overall survivability evaluation.

The principal goal supported by GOVESS will be the comparison of the estimated performance of two vehicles, one of which may be one of the standard comparison vehicles whose performance description will be part of the GOVESS data base. The system is planned to contain extensive help and tutorial facilities for inexperienced vehicle evaluators and will perform many of the programming and operational details currently required for the use of the existing evaluation programs.

20 DISTRIBUTION / AVAILABILITY OF ABSTRACT	21 ABSTRACT SECURITY CLASSIFICATION
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	UNCLASSIFIED
22a NAME OF RESPONSIBLE INDIVIDUAL Mr. Tibor Czako	22b TELEPHONE (Include Area Code) (313) 574-5515 22c OFFICE SYMBOL AMSTA-RSS

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted
All other editions are obsolete

STEVENS INSTITUTE OF TECHNOLOGY
DAVIDSON LABORATORY
Castle Point Station, Hoboken, New Jersey 07030

DAVIDSON LABORATORY REPORT NUMBER SIT-DL-85-9-2533

October 1985

GOAL ORIENTED VEHICLE EVALUATION SUPPORT SYSTEM (GOVESS) -- FUNCTIONAL SPECIFICATION

BY:

M. Peter Jurkat

and

Peter M. Brady, Jr.

QUALITY INSPECTED 1

Accesion For
NTIS CRA&I ☑
DTIC TAB ☐
Unannounced ☐
Justification .....
By .....
Distribution /
Availability Codes
Dist | Avail a. d / or Special
A-1

Prepared for:

U. S. Army Tank-Automotive Command

Warren, MI 48397-5000

Under

Contract DAAE07-82-C-4075

(DL Project 431/5060)

APPROVED:

Irmin O. Kamm, Manager
Transportation Research Group

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED.

TABLE OF CONTENTS

ABSTRACT..... vii
1.0 INTRODUCTION..... 1
2.0 GOALS..... 4
3.0 VEHICLE EVALUATION FACTORS..... 5
4.0 VEHICLE DESCRIPTION..... 8
5.0 EVALUATION CATEGORIZATION..... 11
5.1 MISSION PROFILE AND POSTURE..... 12
5.1.1 Mobility..... 13
5.1.2 Ride..... 14
5.1.3 Obstacle Negotiation..... 15
5.1.4 Survivability..... 18
5.2 COMPARISON VEHICLE SELECTION..... 18
5.3 TERRAIN SELECTION..... 20
5.4 SCENARIO & CONTROL VARIABLES VALUE SELECTION..... 23
6.0 STUDY VEHICLE PERFORMANCE EVALUATION..... 24
6.1 RIDE..... 25
6.2 OBSTACLE NEGOTIATION..... 28
6.3 MOBILITY..... 29
6.4 IMPACT SURVIVABILITY..... 30
6.5 OVERALL SURVIVABILITY..... 31
7.0 OUTPUT PROCESSING..... 31
7.1 RIDE..... 32
7.2 OBSTACLE NEGOTIATION..... 33
7.3 MOBILITY..... 33
7.4 IMPACT SURVIVABILITY..... 33
7.5 OVERALL SURVIVABILITY..... 34
8.0 CONCLUSIONS AND RECOMMENDATIONS..... 34
9.0 REFERENCES..... 37

ABSTRACT

Specification, to a functional level, have been developed for a Goal Oriented Vehicle Evaluation Support System (GOVESS) which, when implemented, will support a user in the performance of vehicle ride, obstacle negotiation, mobility, impact survivability, and overall survivability evaluation.

The principal goal supported by GOVESS will be the comparison of the estimated performance of two vehicles, one of which may be one of the standard comparison vehicles whose performance description will be part of the GOVESS data base. The system is planned to contain extensive help and tutorial facilities for inexperienced vehicle evaluators and will perform many of the programming and operational details currently required for the use of the existing evaluation programs.

KEYWORDS

EXPERT SYSTEMS
MILITARY VEHICLES
MISSION PERFORMANCE
MOBILITY
SURVIVABILITY
VEHICLE PERFORMANCE

1.0 INTRODUCTION

Within the last decade or so the design, development, and evaluation of land and amphibious vehicles have been aided by several computer programs which model many aspects of vehicle performance and capability. Notable among these is a comprehensive mobility prediction model, NRMM, with its two major support models, VEHDYN and OBS78B; a highly detailed armor protection model, TACOME3; a target acquisition and tracking model which takes into account a vehicle's ability to move and find terrain cover; models that predict the signature and detectability of vehicles based on their configuration, powertrain, and electronics; and other, more detailed, models concerning subsystems and components such as drive trains and running gears. The use of these programs has allowed a more analytical and, hopefully, objective development of vehicles than was possible before they were developed. They are, however, not easy to use.

The main objective of the effort whose results are reported here is to develop functional specifications for and assess the feasibility of developing a framework which help the user of these programs in two ways. The first is to help the user more easily perform vehicle evaluations in a way that is directly related to the goals of such a vehicle evaluation; that is, to estimate how well a vehicle will perform the mission for which it is intended in the environment in which it is expected to operate. In this regard, the programs specified here will help the user perform evaluations without requiring him or her to become familiar with the details of how to use the individual programs and how to pass the results of one to the next.

In addition to this, the system is intended to provide an overall collection of programs for vehicle evaluation so that an

evaluator, new to the vehicle evaluation, will not have to spend long periods of time and effort to become familiar with the process of vehicle evaluation assumed by these programs but not extensively explained in many places.

These models and their computer program realizations were developed by different people at different times and places and exhibit a wide variety of user modes. As a result, many inconsistencies and incompatibilities are now part of their combined implementation. Some of these programs run interactively, others in batch mode only; some prompt the user in helpful ways, others offer no assistance for inputs, and present error symptoms from which the true error can only be diagnosed by those familiar with the program; some have ancillary programs associated with them that assist users in their operation while others offer no such assistance.

Furthermore, although the various models concern themselves with different aspects of vehicle performance, they require many of the same vehicle descriptors. Since different people and organizations developed the models, differences (sometimes subtle) in units, definitions, and common practice crept into the data which hamper the comprehensive evaluation of vehicles in all their aspects of performance and capability. If that were not enough, the sheer volume of vehicle, terrain, scenario, and control parameters required makes the coordinated use of these models rather difficult and expensive.

There is currently an effort under way by the Survivability Technology Function of the U.S. Army Tank-Automotive Command (TACOM) to build effective interfaces among these models and common approaches to all their input, operational, and output requirements. This effort, dubbed Vehicle Effectiveness Technology (VET), is planned to disaggregate the models from the vehicle data base, present a common path to any of the required vehicle descriptors, and provide programs

to formulate the data into the exact form required by the evaluation programs. After their execution, other programs of VET will gather the results, present them to the user, and under direction by the user, store the results in the user and/or systems area for later use by designer/evaluators and/or other programs.

The currently planned VET will be of great assistance to the designer, evaluator, and/or user in that it will not be necessary to manually intervene between the execution of the various models to reformat or otherwise process the results of one model to be used by another. Furthermore, the user will not have to perform the functions required to store the input data and results in a way that guarantees their safe keeping and accurate retrieval at a later time.

These essential bookkeeping functions are, however, only part of the difficulty in using this sizable collection of large programs, requiring many inputs, in an effective way. There is little to explicitly help the user to perform the primary task for which he/she is making use of the models.

Generally, the user has a broader goal than merely the calculation of vehicle performance descriptors under a great vaiety of conditions. This goal could be the general evaluation of an existing or well specified vehicle, the comparison of two vehicles (one or both of which may or may not exist), the design of a new vehicle after the essentials of its mission are specified, or some combination of greater and/or lesser activities. The currently planned capabilities of VET are all necessary to the accomplishment of these type of goals, but there is currently little which will explicitly assist the user in this manner. The primary impact of goal oriented assistance is conceptual; it will make evident tasks (phases, steps, activities) which the user may perform to meet his/her goal, will show steps which could be performed quickly at lower, but adequate, levels of

precision than they might have been otherwise performed and may suggest to the user strategies and approaches that were not at first evident. The amount of additional code to be created and run will most likely be modest compared to that already planned for VET and used in any one session, and will certainly be modest compared to that already created and used for the various existing models.

Described in this report is the result of a project to develop, to a functional level, a system of programs which will support a user in the vehicle evaluation and design process; these programs to be used in conjunction with the models and vehicle data to be included under VET. The approach to be used by this system of programs will be guided by the modern program architecture and design practices currently used in systems to which the terms "user friendly", "expert systems" and "decision support systems" have been applied. Thus, described here is a Goal Oriented Vehicle Evaluation Support System, to which the acronym GOVESS will be applied.

2.0 GOALS

As suggested above, and in a background technical memorandum [JURKAT'84], an initial set of high level goals to be supported by GOVESS will include:

G1: Evaluation of an existing vehicle/concept
G2: Improvement of an existing vehicle/concept
G3: Designing a new vehicle
G4: Comparison of two existing vehicles/concepts

The word "existing" here is meant in the sense that data describing the vehicle exists in the VET Vehicle Data Base. The vehicle may or may not actually exist as a prototype or in inventory. Correspondingly, a new vehicle or concept is one for which no data exists in

the data base. (From now on, the word "vehicle" will be used for either an actual vehicle or a concept at some stage of development.)

Goals G1 and G4 may be distinguished from Goals G2 and G3 in that the former are essentially evaluation while the latter are design. Evaluation may be characterized by the assumption that no changes in the vehicle data will be made immediately during the execution of GOVESS whereas the design goal is to specify new vehicle descriptors, prossibly as replacements for existing ones.

At first thought, it would seem that the basic Goal is G1 in that Goal G4 involves the evaluation of two vehicles followed by the comparison of the results (Goal G1 is an objective of Goal G4). Also in achieving Goals G2 and G3 a sufficient set of descriptors of a vehicle is to be completed so that an evaluation of the vehicle can be made. It has been the author's experience, however, that most vehicle evaluators have a standard in mind when making judgements about how good, bad, capable, etc. a vehicle is. This standard is often another vehicle, one that is familiar to many people in many situations. Initially, the people who helped develop NRMM used the M151, M35, M-113 and M60 as comparison vehicles. It would seem, in fact, that Goal G4 is the basic goal and this report will therefore concentrate on what is meant by satisfying Goal G4.

3.0 VEHICLE EVALUATION FACTORS

In the military environment, vehicles may be evaluated by several major factors. Of these, the VET program is currently concentrating on mobility and survivability, which include:

F1: Overall survivability in a one-on-one encounter (Program SOM),

F2: Impact survivability on being struck by one or several rounds (Programs TACOME2 and TACOME3),

F3: Overall mobility, on- and off-road (Areal and Road Modules of Program NRMM as in Volume I of [NRMM'79]),

F4: Ride "comfort", to avoid human fatigue and/or injury, protect cargo, and allow passengers and drivers to perform their duties (Program VEHDYN [VEHDYN'74]), and

F5: Obstacle negotiation, or the ability of the vehicle to cross terrain features such as rivers, embankments, fortifications, and natural and man-made debris (Programs OBS78B and GAPMOD as in Volume II of [NRMM'79] and [GAPMOD'83]).

Each of these factors is evaluated using the programs listed and other, unmentioned, support programs. (See for example [NOVAK '82].)

Currently, these programs yield numeric measures which give quantitative descriptors of the extent to which a vehicle is mobile and/or survives with respect to each of these factors. These are:

M1: The probability of the vehicle surviving the one-on-one encounter,

M2: The probability that the vehicle, after being hit by enemy fire, is totally ineffective (overall kill), unable to move (mobility kill), and/or unable to return fire (firepower kill),

M3: The average speed with which the vehicle can traverse the portion of a given terrain on which it can move the fastest (V_X%), the overall time it takes a vehicle to traverse a given path, and/or measure to indicate special situation capability such as VCI_1 for soft soil areas,

M4: The average absorbed power of a human at a certain location in the vehicle and/or the peak acceleration at that location, and

M5: The average and maximum tractive effort required to traverse an obstacle and the minimum clearance or maximum interference while doing so.

These numerical descriptors, however, do not tell the user how good the vehicle is unless the user has extensive experience both with actual vehicle performance and the numerical descriptors themselves. In addition, certain values of these descriptors may be considered "good", for example, for tactical trucks of a certain category, whereas they may be considered unacceptable for combat vehicles.

Clearly, at least two additional conditions have to be included to evaluate a vehicle. At a high level of abstraction, these may be stated as:

- The intended purpose of the vehicle and its mission, and

- The capability of other vehicles with similar purpose and missions.

The last condition again emphasizes the basic nature of Goal G4.

Since GOVESS is intended to help non-expert users to evaluate vehicles, it cannot be assumed that these users will know how to properly evaluate numerical measures such as M1-M5, much less how to categorize the vehicle mission and niche in terms that the vehicle evaluation programs, called to measure factors F1-F5, can understand. This means that, when the user wishes, GOVESS will need to be able to choose appropriate terrain files and develop the so-called scenario variables; that is, those variables that tell the evaluation programs what terrain, path, and operating conditions to use. In addition, GOVESS will have to be able to choose appropriate comparison vehicles, from the existing ones, to use as "standards".

4.0 VEHICLE DESCRIPTION

One of the prerequisites to using the programs mentioned above in the vehicle evaluation process supported by GOVESS is that a rather complete description of the vehicle must be available in engineering terminology. This includes geometric measurements (such as height, wheel spacing, ground clearance, armor thickness), component performance (such as engine torque-speed data), and whole vehicle performance (such as maximum power required to override obstacles of certain height).

A set of data sheets will be available to assist the user in gathering a complete set of vehicle descriptors. Currently, such a set exists for the overall mobility, ride and obstacle crossing programs (F3-F5); similar ones will be developed for the overall survivability and impact survivability factors (F1-F2). These sheets request vehicle data in forms that seem somewhat natural for the vehicle designers, and/or for actual measurements when a vehicle exists. These sheets are designed so that various combinations of them are required for the various vehicle evaluation activities.

These vehicle descriptors are independent of any one of the programs to be used in the vehicle evaluation process. Various of the programs require essentially the same vehicle descriptor in different forms, as, for instance, locations on the vehicle in the obstacle negotiation program are referenced to the "hitch" while in the ride program they are referenced to the CG. To meet this requirement a two step procedure will be used to compose the vehicle data files actually to be used by the evaluation programs. The basic repository for the vehicle data will be the VET Data Base as currently defined in [VETDICT'83] and [GROSKY'83]. This will be a single reference scheme where all the data required by VET evaluations will be stored. The existence of a central data repository will help assure data integrity and precision.

For the first step, there will be a screen form available for each of the vehicle data sheets so that the user may enter the data into the vehicle data base by transcribing the data from the sheets; or the sheets may be skipped entirely and the data entered directly. The programs which will display the screen forms to the user will also deposit the vehicle descriptors into the VET Data Base. Alternately, it may be desirable to allow the user to copy portions of the VET Data Base into his or her workspace; this to avoid corruption of the main VET Data Base. In the latter case, the screen display programs will deposit vehicle descriptors in the users workspace.

For the second step, a set of programs to be made a part of GOVESS will compose the vehicle data files required for the individual program components by selecting the appropriate numbers from those entered in the VET Data Base. A significant start has been made in the development of these vehicle descriptor conversion programs by those reported in [NOVAK'82] for mobility, ride and obstacle crossing evaluation. GOVESS will also include a program to help

the user compose the vehicle input data for the impact survivability evaluation as prescribed in [BONKOSKY'77].

There are several groups of vehicle parameters for which considerable effort is required to determine their numerical values. Among these are included such items as the vehicle speed vs. surface roughness relationship at a given level of absorbed power, the armor envelope configuration, and the forces required to override obstacles of a given height, width and approach angle. To determine these values, and others like them, it is required to perform full scale measurements and/or run computer programs such as VEHDYN and OBS78B with a group of input values; this can take time and expense. Often this expenditure is required, but there are also studies where the vehicle being evaluated is similar to another vehicle, or the object of the study is to determine the effect of variation of some components and the investigators do not wish to spend project resources on the development of other components. In these latter cases it may not be worth the time and expense to determine vehicle parameters and performance measures for components and capabilities not being investigated.

To address this situation GOVESS will support the ability for a user to determine or specify some vehicle parameters and performance measures by analogy, so to speak. That is, the user will be able to say that the study vehicle is like another vehicle, only different in some particular aspect, such as some percentage smoother or faster or some other way. GOVESS will then copy the appropriate vehicle descriptors of the other vehicle and adjust them according to the difference indicated by the user.

Since it cannot be expected that all users will be thoroughly familiar with all the vehicle descriptors used in the above evaluations, GOVESS will allow the user to ask for explanation of the definitions

and possible measurement techniques of each vehicle parameter. It may be desirable to produce explanatory graphic images with labels on those terminals that support graphics. If this entire capability is not desired, it may be sufficient to refer to the page number of the appropriate document when the value of a particular parameter is requested.

5.0 EVALUATION CATEGORIZATION

Before starting the evaluation of a vehicle, GOVESS will help the user to establish the standards that will be used to judge the results of the evaluation as well as the conditions under which the vehicle will be evaluated. The user will always have the option to decline the help of the system and directly specify the standards and conditions. This will include the specification of standards for vehicle performance, selection of a terrain file and a path across it (although the choice of a path may not be implemented until much later), and the choice of scenario variable values (such as wetness conditions for mobility evaluation or seasons for visibility in the survivability analysis).

These conditions and standards will most likely fall into the broad categories that are currently used for vehicle classification, such as "combat", "forward support" and "tactical". For each of these categories a group of terrain files, appropriate scenario and control variables, and one or two "standard" vehicles will be specified. In addition, there will be a unique set of descriptors, measures and special conditions specified with each category, as for instance, tactical vehicle mobility will be measured by V_{50} as opposed to V_{80} for combat vehicles. The user will have the ability to choose the elements of this set, but defaults will be available.

Initially, during system development and testing, it is planned to have a menu of vehicle categories available. The categories will

be those used by several expert vehicle evaluators. Later, as the system matures, a capability will be added to GOVESS which will allow the system to conduct a dialogue with the user to define the category in which he/she wishes the object vehicle to be evaluated. For this capability the categories will be associated with common English words used to describe the role and functionality of the class, such as "reconnaissance". It may happen, however, that the initial menu categories will prove useful and sufficient for most purposes.

5.1 MISSION PROFILE AND POSTURE

The most highly developed procedures for the specification of a vehicle's mission and posture exist in the overall evaluation of mobility (F3 and M3). As a result of several relatively formal evaluation studies conducted over the last decade ([WHEELS'72], [HIMO'76], [TACV'8/78], [TACV'11/78], [RANDOLPH'83]) and some that are still in process [NUTTALL'84], the categorization of missions and the mobility requirements of vehicles to fulfill these missions has been formulated in engineering terms as a requirement for proportions of on- and off-road travel and the percentage of all on-road and off-road terrain that the vehicle is required to negotiate. The actual average speed that the vehicle can travel on these proportions of the terrain is then used as an indicator of its mobility.

Although possibly not the most suitable in all cases, for now the mission profiles and postures used in these mobility studies will be adopted for all five factors of vehicle evaluation considered by GOVESS. Since in all cases the system will allow the user to specify other mission definitions (as far as implementation flexibility allows), survivability criterial based on other considerations can be adopted as desired.

Based on the results of the above studies, and unless the user indicates otherwise, GOVESS will recommend that the user choose

one or more of the mission profiles indicated by:

Reconnaissance
Combat
Combat Support - including artillery movement
Combat Service Support - including combat engineering
Tactical High Mobility - Brigade area primary mobility level
Tactical Standard Mobility - Division area primary mobility level
Tactical Support Mobility - Corps area primary mobility level

These categories are not intended to be mutually exclusive, in particular combat service support may include most if not all of the tactical high and possibly some of the tactical standard mobility requirements. Rather, these are words to help the user position the analysis in categories that hopefully have meaning independent of the mobility measures stated in M1-M5 above.

5.1.1 Mobility

Unless revised by the user, GOVESS will associate with each of these mission profiles a percentage of required travel on primary roads, secondary roads, trails, and cross country for both offensive and defensive posture, when this categorization is meaningful. The difference in the requirements associated with these postures is that for defensive postures the cross-country terrain is expected to be used more since this posture can usually be selected with more advanced notice than the offensive one, resulting in more familiar terrain.

The third factor (besides mission profile and posture) that will determine the percentage on- and off-road requirements is the geographical area in which the vehicle is expected to be deployed. Different types of terrain obviously call for different tactics.

5.1.2 Ride

The mission and posture related requirements for ride can be derived partly from the mobility considerations. For mobility evaluation purposes the quality of ride over a given terrain is the maximum speed a vehicle can travel without subjecting the driver, or another person or object located somewhere in the vehicle, to more than a certain "discomfort" level. The discomfort level is specified as the power due to vibrations absorbed by the driver, occupant, and/or cargo, this measured in watts and calculated by a filter like procedure from accelerations at the driver's station or at some other location. For more details see the section Vehicle Ride Dynamics Model in [ANAMOB'71].

It is supposed that, on a given terrain, the higher the speed of a vehicle the more power will have to be absorbed by the driver and/or other vehicle occupants and/or cargo. It is further supposed:

- that the driver or commander will adjust the speed of the vehicle to moderate the discomfort due to vibrations, and
- that the level of discomfort to be tolerated is related to:
  - o the requirements of the mission,
  - o the tasks to be performed while the vehicle is in motion (controlling, aiming and firing, reading maps, ...), and/or
  - o the motivations of the occupants.

These considerations result in mission and posture requirements for ride being stated as tolerable absorbed power levels associated with these conditions. It has been the practice to consider 6 Watts absorbed power in the vertical direction to be "standard" ride criterion for most mobility analyses independent of mission and posture requirements and this will be the level used by GOVESS unless otherwise specified by the user.

Special mobility studies have been performed recently [NUTTALL'84] in which multiple levels of absorbed power have been used depending on the mission, profile, and type of vehicle. Typical levels have been 12 Watts vertical absorbed power for tracked vehicles and 15 Watts for wheeled vehicles under reconnaissance, combat and combat support missions. The user will need to consider how many and what level to use in the ride performance evaluation to be done as a preliminary to overall vehicle mobility and/or survivability evaluation, as described below.

The ride evaluation program, VEHDYN, is often used by vehicle evaluators independent of mission and posture requirements. This use is to provide input data about a vehicle to overall mobility evaluations and/or special ride evaluations under specific conditions in order to evaluate particular design features. The user will have the option to ignore the mission and posture specification entirely and proceed directly to the comparison vehicle selection and/or terrain selection.

5.1.3 Obstacle Negotiation

For mobility evaluations using NRMM [NRMM'79] obstacles have been classified into two categories, obstacles and gaps.

The term obstacles is used for those natural and man-made impediments to vehicle travel that the vehicle appears to encounter in a random fashion and which it might be expected to override without substantial deviation from its path. They are actually natural mounds and ditches, tree stumps, logs, dikes and small walls. They may be avoidable, such as logs, or not, such as hedgerows and rice paddy embankments.

For modelling and analysis these obstacles have been stylized into categories all exhibiting a symmetrical trapezoidal shape in a cross-section parallel to the direction of the vehicle's path. They are grouped into classes according to their height, width and approach/departure angle. During the analysis to predict cross-country travel, NRMM considers both the option to modify the path of the vehicle from a straight line to avoid these obstacles and the option to override them. When the vehicle can either avoid or override them, NRMM chooses whichever option produces the highest speed-made-good for the particular terrain unit.

No differentiation is made in the mobility analysis for mission or other vehicle travel requirements when this group of obstacles is considered. The analysis tries to find the maximum speed-made-good regardless of mission, posture, etc. This means that the evaluation of the vehicle's ability to negotiate obstacles is independent of these considerations and is performed as a prelude to an overall mobility evaluation.

This is not the case for the evaluation of a vehicle's gap crossing ability. Gaps, also often called "linear features" in mobility analysis, are geographic and cultural features that are designated by lines on 1:50,000 maps. These are actually streams and rivers, railroad and road embankments, and ditches and mounds from whatever sources they come. They are usually much larger than the above mentioned

obstacles and are usually unavoidable in the sense that they are truly unavoidable or require substantial deviation from the intended overall direction of travel. For mobility analysis these gaps are required to be crossed, although in the process the vehicle may actually travel along them such as when travelling down a stream to look for a suitable egress location.

As with ride considerations, the gap crossing capability of vehicles related to their mission and posture requirements can be specified from mobility considerations. Except for remote regions of the world these same obstacles are required to be crossed by commercial and pleasure vehicles as part of their normal use. For this purpose bridges, fills, and cuts are constructed to keep slopes down to a level that the vehicle can negotiate. Since military vehicles are usually more capable than commercial vehicles, although sometimes heavier and wider, it will be assumed that military vehicles can use these passageways when they exist. During some missions these passageways may not be available to military vehicles, possibly because they are destroyed or too exposed or mined.

These considerations lead to the mission and posture related obstacle negotiation requirements that can be stated in terms of the number or percentage of obstacles that a vehicle is required to cross unaided by engineered structures or assistance. Vehicles being evaluated under reconnaissance or combat conditions will be tested against more obstacles, or more severe ones, than would vehicles being evaluated under other missions. Operationally, this becomes a matter of including certain categories of obstacles in the terrain files used for vehicles being evaluated under the various mission and posture categories.

As with VEHDYN, the obstacle crossing modelling programs, OBS78B and GAPMOD, are used by vehicle evaluators independent of

mission and posture requirements. In these cases the user will be able to proceed directly to comparison vehicle and/or terrain selection, indicating that mission and posture considerations are to be ignored.

5.1.4 Survivability

Both overall survivability and impact survivability (Factors F1 and F2) are by their nature reconnaissance and/or combat situations, so that, unless the user specified otherwise, the combat mission considerations and an offensive posture will be used by GOVESS.

5.2 COMPARISON VEHICLE SELECTION

For each of the mission profiles and posture categories, experts often use some vehicle as the "standard" to compare the vehicles being evaluated. This "standard" is usually not meant to pose a level of capability that study vehicles are intended to achieve; rather, it is designated as a fixed level of performance that study vehicles are to be compared against. It is preferred that these "standard" vehicles should be vehicles whose capability is known to a large segment of the people who will do vehicle comparisons, and that they have actually been used in the mission, posture, and location chosen for the evaluation.

It may be true that no such vehicle actually exists in hardware; the expert may just have a set of performance capabilities in mind. In this case it may be necessary to create a hypothetical vehicle for comparison purposes and to develop suitable display techniques to communicate to the non-expert user what this hypothetical comparison vehicle is able to do.

One of the requirements for an existing vehicle in GOVESS to be designated a comparison vehicle is that all numeric measures that can be used to evaluate a vehicle be available to the program.

This will include those listed above, M1-M5, and any others that will be specified as this project proceeds.

The system will have the capability to designate arbitrary vehicles as comparison vehicles for new or existing categories. It may also become convenient or necessary to change the comparison vehicle for a category from time to time. One type of evaluation where this capability may prove essential is when a vehicle is being evaluated as part of a mixed fleet, such as a combat group consisting of tanks, artillery and the associated support and engineering vehicles. Here the basic requirement may be that the study vehicle not be any slower than the slowest group member vehicle under the various conditions the group may encounter. In this case, the comparison vehicle may change the mission profile, posture and theatre of operation changes.

The following vehicles will be recommended for comparison vehicles by GOVESS. In each category, the first vehicle listed will be the one used unless more refined categories are desired. The other vehicles listed will be used when further categorization by weight and/or wheeled/tracked is specified.

V1. Reconnaissance:
- M113A1 (tracked, 13 ton)
- M3 (tracked, 25 ton)
- HMMWV (wheeled)

V2. Combat:
- M1 (tracked, 60 ton)
- M2 (tracked, 25 ton)
- LAV (wheeled)

V3. Combat Support:
- Same as Combat

V4. Combat Service Support:

M35A2 (wheeled, 5/2 ton)

HMMWV (wheeled, 5/4 ton)

M813A1 (wheeled, 5 ton)

M125E1 (wheeled, 10 ton)

M113A1 (tracked)

V5. Tactical High Mobility:

M113A1 (tracked)

HMMWV (wheeled, 5/4 ton)

M813A1 (wheeled, 5 ton)

HEMTT (wheeled, 10 ton)

V6. Tactical Standard Mobility:

M35A2 (wheeled, 5/2 ton)

M813A1 (wheeled, 5 ton)

M125E1 (wheeled, 10 ton)

V7. Tactical Support Mobility:

CUCV (wheeled)

5.3 TERRAIN SELECTION

Except for impact survivability, the evaluations supported by GOVESS will require data describing the terrain over which the vehicle is expected to operate. The user will have some idea as to what that terrain should be, either generally in terms of common military and/or civilian characteristics, or more specifically in terms of the characteristics important for survivability and/or mobility.

It cannot be expected that all users will be familiar with the terrain terminology used for survivability and mobility modelling. GOVESS will give the user the option to be presented with a short tutorial about the terrain measures used, how they relate to common military/civilian terrain descriptors, and some of the criteria that

the user may wish to consider when finally selecting the actual terrain file(s) to be used in the evaluation.

Upon indication that the terrain tutorial is to be skipped or upon its completion, the list of available terrains will be presented to the user as geographic regions. The actual terrain file to be used for the evaluation will depend on the evaluation to be done (overall survivability, ride, etc.), and on the mission and posture selected for the vehicles. The user will select a terrain and proceed with the evaluation or will indicate that more information about the terrain is needed.

If the user wishes more information, it will be possible to choose a terrain and ask the system to provide more information about that specific one or to ask the system to help select a terrain by giving conditions to be met (for example: no more than 15% covered by forest, etc.). The list of conditions against which terrains may be chosen will be available as a menu to the user. The information to be available about each terrain will include:

- its location, possibly shown by a crude map,
- an overall characterization in terms of commonly used topographic, natural, and cultural features,
- statistical or other descriptions of the specific terrain features included in the terrain files, such as terrain unit type, slopes, soil strengths, obstacles, visibility, ground cover, number of terrain units, etc., and
- the performance level of the comparison vehicle in terms of overall mobility and survivability.

Eventually the user will select a region or terrain. GOVESS will then retrieve a specific terrain file keyed to:

- the region,
- the evaluation to be performed,
- the mission required, and
- the posture of the group using the vehicle.

The implementors of GOVESS might want to consider a centralized facility to manipulate terrain files. Users will not be likely to change terrain file content so they may be considered read-only files, and may never have to be copied into the user's workspace. A storage structure consisting of a terrain file dictionary whose entries reference the actual terrain files may be possible. For each terrain file, the dictionary should contain entries for the location of the terrain file itself, the location of the terrain information file containing the data specified above, and the location of a system file containing information needed to reference the file and to specify the contents and format for those porgrams that actually need to read the file.

Additional considerations need to be given to the terrain files used by the Survivability Optimization Model (SOM). The analysis here is by its nature one which requires the study vehicle to move along a specified path, rather than omni-directional travel over many paths through an area. Furthermore, SOM actually uses several different terrain files; one indicating the ground elevations, a second giving the soil and surface features, and the third specifying the path to be travelled.

The ground elevation specifies the altitude for a given longitude and latitude, or x- and y-ground coordinate in some local reference scheme. It is constructed from the digitized maps produced by the Defense Mapping Agency as part of their regular mission. Since these files are widely available it may be desirable to allow users to create SOM ground elevation files from DMA files without the intervention of the GOVESS administrators. If this is the case, GOVESS

may need to include such a program, which would create the SOM ground elevations files in the user's workspace. Procedures would need to be developed to allow such ground elevation files to be incorporated into the central GOVESS terrain data base.

The soil and surface feature file of SOM is to provide the information necessary for the mobility model to estimate speed along the path to be travelled. It may be desirable to collect the soil and surface information for each terrain unit along the path in a separate file, invoke a mobility evaluation program such as NRMM, and build a separate file of terrain units versus speed. This would remove the requirement to perform mobility evaluation in SOM.

The third terrain file used by SOM is the path specification file. This file is developed by the user, possibly in conjunction with his or her client when the evaluation is planned. GOVESS may assist this path development process by supporting the display of topography on graphics terminals which will communicate to the user the possible choices of travel by the study vehicle. If good topographic maps are available, this feature may not be necessary, but it should be implementable rather easily, since the most time consuming part of the task, namely the development of the ground elevation file in the format of a triangular or quadrilateral planar elements has to be done for the regular SOM ground elevation file anyway. Then a program such as MOVIE.BYU can readily show topography at oblique angles.

5.4 SCENARIO AND CONTROL VARIABLES VALUES SELECTION

The term "scenario" is used here for all the specifications that indicate the conditions under which a particular run of an evaluation program is to be done. These include local, relatively transient conditions on the terrain chosen (such as snow or fog or smoke),

or particular components of the vehicle that are to be operational or not (such as central tire inflation systems).

The user will have complete freedom to choose all the scenario variable values desired for the evaluation. Alternately, GOVESS will choose them for the user according to the procedures used in the mobility evaluation studies recently conducted and referenced above. These include:

S1: three runs will be made on each terrain with its surface specified as it may be found during:
- the dry season
- the wet season
- under some extreme condition typical for the particular terrain, such as snow for northern regions or sand for desert regions,

S2: all features of the vehicle which are intended to enhance its performance will be assumed to be operational and in use by the driver (such as central tire inflation systems), and

S3: all other operational parameters, such as minimum speed under any conditions and maximum deceleration during braking, will be set at default values to be communicated to the user.

6.0 STUDY VEHICLE PERFORMANCE EVALUATION

Once the user has specified (and/or GOVESS has chosen by default) the study vehicle, the comparison vehicle, the study mission and posture, the terrain and the scenario, the actual study vehicle evaluation can begin. The full evaluation under GOVESS is normally done in several major steps, corresponding approximately to the evaluation factors listed above. In fact, to perform overall mobility

evaluation, information normally supplied by ride and obstacle negotiation evaluation is required. Similarly, to perform overall survivability evaluation, information normally supplied by the impact survivability model is required.

It will not be necessary to perform the full ride, obstacle negotiation, and impact survivability evaluation to be able to run the mobility and/or overall survivability models. If, by this stage in the evaluation procedure, the complete set of vehicle descriptors is not available and/or the user wishes to change some of them, several different options will be available to supply the necessary information, among them:

- user entry,
- analogy,
- analogy with modification, and
- comparison vehicle default.

6.1 RIDE

The normal result from a ride evaluation is a table showing the relationship between surface roughness, measured by the root-mean-square (RMS) of the elevation along the path to be travelled by the vehicle, and the maximum speed the vehicle can maintain without having the absorbed power in the vertical direction at the driver's station exceed a certain value, such as 6 Watts. This table, and possibly another one for a higher value of absorbed power, is entered as a vehicle parameter in the vehicle descriptors used as the input to a vehicle evaluation.

The program usually used for ride evaluation, VEHDYN, is a time domain simulation of the motion and forces to which a vehicle is subjected when it travels over an uneven terrain at a constant

forward speed; the average absorbed power in the vertical direction is calculated from these time histories. Alternatively, the absorbed power may be measured on the vehicle travelling an actual course at a constant speed. In either case the result is a relationship of absorbed power versus speed on a course of given roughness, not speed versus roughness at a given absorbed power.

To achieve the desired relationship, speed versus roughness, many individual runs of the simulation have to be made, each time changing the speed in order to find one for which the absorbed power will be near 6 Watts, or whatever level of absorbed power is desired. The search for this speed is affected by the existence of a speed at which the vehicle's natural heave and/or pitch frequencies occur, with the result that very large values of absorbed power are exhibited. Beyond these speeds, more moderate values of absorbed power result and it is possible that there is a speed for which 6 Watts absorbed power exists in this range. This would yield a value of speed that the vehicle would actually achieve only with difficulty since in order to reach the speed the vehicle would have to pass through a speed at which the natural heave and pitch frequencies occur.

If the user wishes, a list of courses and their roughness, as measured by rms elevation, will be exhibited. The user may select one of the courses and ask that GOVESS invoke a run of VEHDYN at a certain speed. GOVESS will format the input files (vehicle, terrain, and scenario and control) and initiate the run. The results will be exhibited to the user who may then choose a different speed and/or a different course. Multiple runs like this will eventually allow the user to develop the speed versus roughness relationship at any level of absorbed power desired.

Alternately, GOVESS will support the automatic search for the speed versus roughness relationship at a given level of absorbed

power. It will most likely be recommended that the user invoke this facility as a background job to the operation system of the computer on which GOVESS is being used, since it is likely many runs of VEHDYN will be invoked and they can take a long time. The development of this automatic search will involve the creation of a small expert system to examine the morphology and characteristics of the vehicle and to estimate the range of speed at which VEHDYN will be run to determine the desired absorbed power.

This automatic speed versus roughness relationship development is likely to be expensive and to take a long time if left entirely to its own control. An intermediate capability will exist to allow guidance by the user; one, in which the user indicates a similar existing vehicle from which GOVESS will estimate the speeds at which to run VEHDYN, and the orther, in which the user gives the stimated speed ranges that he/she expects the vehicle will exhibit in order to yield a given value of absorbed power over a course of certain roughness.

Still another option will be for the user to ask that the ride characteristics of the comparison vehicle be used for the study vehicle. This will effectively remove any differential between the vehicles due to their ride characteristics.

Similar considerations exist for the development of the speed versus height relationship at 2.5g vertical acceleration and speed versus obstacle spacing at 2.5g vertical acceleration, which are the other tables developed by the ride evaluation that are used in the overall mobility evaluation.

Several facilities will exist in GOVESS to support ride evaluations other than for overall mobility evaluation. One of these is the ability for the user to enter a course of a particular elevation

profile and to have GOVESS calculate its roughness measures. These will include the rms of the elevation and the exponent of the exponential term of the power spectral density. These profiles will be maintained in the user's workspace.

A second support facility will be available to generate terrain profiles with half round obstacles of various heights and spacings.

6.2 OBSTACLE NEGOTIATION

The normal results of obstacle negotiation evaluation is a table that relates the average force, the maximum force, and the minimum clearance/maximum interference shown by a vehicle as it overrides a stylized mound or ditch of trapezoidal profile with a given height, width and approach angle. This table is included in the list of vehicle parameters used as input to the overall mobility evaluation of a vehicle.

The development of this table is a relatively straightforward matter since the obstacle negotiation simulation program, OBS78B, was written to create an output file which can be included directly in the mobility evaluation input file. A file of obstacle profiles has been developed which can be used as an input terrain file to the obstacle negotiation evaluation to support this development.

To perform a normal obstacle negotiation evaluation, the user will just indicate that this is desired and GOVESS will do the rest.

To perform special purpose obstacle negotiation evaluation, facilities similar to those in the ride evaluation will exist. These will consist of programs which will help the user develop obstacle profiles in the proper format for input to the obstacle negotiation simulation programs.

6.3 MOBILITY

The objective of the mobility evaluation is to determine the speed with which the study vehicle can traverse the terrain units chosen above under the conditions specified. This is done by the vehicle and terrain preprocessors and operational modules (AREAL and ROAD) of the NATO Reference Mobility Model.

The preprocessors and operational modules of NRMM may be invoked after the speed versus surface roughness, speed versus obstacle height, and force and interference versus obstacle geometry tables have been entered into the vehicle data descriptors. If the user has used GOVESS to specify the mission, posture, terrain and scenario characteristics, GOVESS will be ready to perform the mobility evaluation runs of NRMM by just being asked to do so. If the user has not used GOVESS to specify all the above and not all of them have been specified, GOVESS will indicate the missing ones and prompt the user to supply them or to have the user indicate how GOVESS should get them, or, finally, to return to a previous stage in the process.

The AREAL module of NRMM contains a model whose output is a list of terrain units, the maximum speed achievable by the vehicle on each terrain unit (both averaged across up, down, and cross slope travel as well as speeds for each of up, down, and cross slope), and several levels of discretionary output such as speed limiting factors and reasons for any NOGO's. The ROAD module produces a similar list but only includes travel up and down slope. The normal summary report of an overall mobility evaluation will be the speed profile of the study vehicle on the selected terrain plotted with the speed profile of the comparison vehicle on the same terrain. The speed profile is calculated by ranking the terrain units from those on which the vehicle can go fastest to those on which it is slowest or cannot go at all, and to average the speed on each initial segment

of this list. The result of this calculation is displayed by plotting the average speed against the percentage of the total terrain included in the evaluation.

6.4 IMPACT SURVIVABILITY

The impact survivability evaluation programs calculate various kill probabilities for each impact event. An impact event is defined as the approach of one of a variety of rounds, like kinetic energy, HEAT, etc., in one of two configurations, discrete or distributed. For each of these events, the programs (TACOME2 and TACOME3) calculate the probabilities of overall kill, mobility kill, firepower kill, and logical combinations of these for the overall vehicle and various components, such as the crew, the suspension, the gun, the fuel and the ammunition. These results are displayed in a table.

In addition the results of the impact survivability evaluation will be shown in graphical form. This will be a view of the vehicle from above with a radial plot of probability of survival versus the direction (azimuth) of impact.

For any set of runs of one of the impact survivability models, GOVESS will check to see that the vehicle definition is complete, and show that configuration to the user for armor and component input data verification using the plotting programs if an appropriate output device (plotter and/or graphics terminal) is available. Upon user indication that he/she wishes to proceed with the evaluation, the various round parameter choices will be displayed for specification by the user. Alternately, if the user knows what is to be done, a file with those specifications may be read by GOVESS.

The user will specify the type of round, its type, and the elevation and azimuth from which it is to approach the vehicle. Ranges for the latter two will indicate that multiple runs with para-

meter variation are to be done. GOVESS will invoke the appropriate program and proceed with the various runs.

6.5 OVERALL SURVIVABILITY

The regular output from the overall survivability model, SOM, is a table containing the overall probability of survival for the entire encounter, and the probability of various combinations of overall kill, mobility kill and firepower kill.

In addition graphical results will be produced. These will show a plot of the individual kill probabilities, or various combinations versus the position along the path given in distance from the start, or time from the start. A readily available option will be a plot of the percent exposure of the vehicle to the threat versus path position.

7.0 OUTPUT PROCESSING

Since each of the evaluation programs to be included under GOVESS was originally designed and developed for a purpose less broad than the GOVESS goals, the output included in the evaluation programs is generally not suitable for further evaluation. Rather than change the individual evaluation programs it has been the practice to use the outputs of the evaluation programs as inputs to further "output processing" programs to allow customized results for various types of evaluations. GOVESS will continue this practice in that various programs will be available to refine, display, aggregate, summarize, compare, etc. the results described above..

In order to support the basic goad, G4, of comparing two vehicles, the performance evaluation of the study vehicle (see previous section) will be subjected to the processing specified in this section and then displayed with similar processed evaluations of the comparison

vehicle. To help the inexperienced evaluator, it may be possible to display a band of variation about the results of the comparison vehicle such that if the study vehicle results fall within this band, the experts consulted during the construction of GOVESS would conclude that no significant difference exists between the study vehicle and the comparison vehicle.

Comparison displays like this will be generated for each of the factors listed below.

7.1 RIDE

The ride evaluation program, VEHDYN, normally produces values of absorbed power and peak vertical acceleration at a location on the vehicle as its motion is simulated while traveling at a given speed over a given course. Each run of VEHDYN produces only one point in the relationship between absorbed power, vehicle speed, and course roughness. A useful output processor which GOVESS will support is the production, on the screen and on a plotter, of all the combinations of cross-plots between these variables while the third has a specified value.

VEHDYN is a time domain simulation of a vehicle's motion as represented by the solution of a system of differential equations. Values for many variables are calculated in the process of solving these differential equations numerically. Many of these values have physical significance. GOVESS will contain an output processor for ride evaluation which will plot the simuated time series for these variables and support the calculations of summary descriptors of these time series, such as the average amplitude, root-mean-square amplitude, and possibly the autocorrelation and the power spectrum.

7.2 OBSTACLE NEGOTIATION

The principal output processing performed after obstacle and gap crossing evaluation is the production of pictorial representation of the vehicle motion. This is currently being done on a pen plotter from special output files produced by these programs.

A major enhancement of this capability to be supported by GOVESS is the production of these pictorial representations as static and/or animated displays on designated graphics terminals.

7.3 MOBILITY

A currently existing output processor of mobility evaluation performed by NRMM to be supported by GOVESS will be the speed limiting and GO/NOGO diagnostic program [BRADY'80]. Its use requires that the output from NRMM include some of the intermediate results, such as the maximum speed as limited by various factors such as soil/slope/vegetation, ride, visibility, etc. From these the diagnostic program produces tables such as the percentage of terrain units on which the speed was limited by each factor.

7.4 IMPACT SURVIVABILITY

An output processor for impact survivability whose development has begun, and which should be included in GOVESS, is a graphical display of when the vehicle is most vulnerable to impact. This can take the form of an oblique view of the vehicle from any one of the various azimuth angles that were used in the impact evaluation showing, from that angle of attack, the vulnerability of the various places on the vehicle exposed to that direction. The data for this is readily available from the calculations within the impact survivability models and the display program ahs been started. It is not known if any documentation exists for the existing code.

7.5 OVERALL SURVIVABILITY

The tabular and graphical outputs of the SOM are sufficiently self explanatory so that little further processing is necessary other than the display of the SOM results for the comparison vehicle next to that of the study vehicle.

8.0 CONCLUSIONS AND RECOMMENDATIONS

The vehicle evaluation support, as specified for GOVESS, is feasible and will significantly enhance the capability to perform mobility and survivability evaluations, certainly for inexperienced users but even for experienced ones.

It is recommended that GOVESS be implemented by stages and components. These individual components will be useful in their own right, and the experience with them by both experienced and inexperienced users will indicate how the entire system will be used and what its most important features will be. In this regard, it is recommended that the following implementation schedule be considered:

1. An executive program to manage the execution of the NATO Reference Mobility Model, its associated obstacle crossing model (OBS78B), dynamics model (VEHDYN), and the input data checking programs for them including the preparation and verificiation of vehicle data to be used in the system and screen form entry programs for vehicle data for all the programs to be included in GOVESS;

2. Programs to assist the user in the development of NRMM data files by performing the automatic adjustment of tractive effort versus speed data and the [illegible]ation of ride data;

3. A programming and coding specification of the overall GOVESS;

4. A skeleton implementation of GOVESS including the mobility analysis (NRMM and its associated vehicle, terrain, scenario and control data);

5. Extensive help and explanation support for the previous skeleton system to test its tutorial capabilities for inexperienced users;

6. The output processors for the skeleton system including the automatic display of the results for the study vehicle with the comparison vehicle;

7. Inclusion of the impact survivability analysis in GOVESS;

8. Development of ground elevation, soil and surface features, and path specification files for the SOM;

9. Programs to graphically depict the SOM terrain as it would be seen from any point near it; and

10. Inclusion of the survivability analysis in GOVESS.

THIS PAGE INTENTIONALLY LEFT BLANK!

9.0 REFERENCES

[ANAMOB'71] A.A. Rula and C.J. Nuttall, Jr., "An Analysis of Ground Mobility Models (ANAMOB)", U.S. Army Engineer Waterways Experiment Station Technical Report M-71-4 (July 1971).

[BONKOSKY'77] B. Bonkosky, "Preparation of the Finite Element Configuration Data Deck for Ballistic Design and for Survivability Evaluations", U.S. Army Tank-Automotive Research and Development Command, Technical Report No. 12238 (March 1977).

[BRADY'80] P.M. Brady, Jr., "An Output Diagnostic Program for the NATO Reference Mobility Model", Davidson Laboratory Report SIT-DL-80-9-2183 (December 1980).

[GAPMOD'83] P.M. Brady, Jr. and M.P. Jurkat, "Analysis of Vehicles Crossing Gaps -- A Fording Model", Davidson Laboratory Report SIT-DL-83-9-2370 (September 1983).

[GROSKY'83] W.I. Grosky, "A Data Model for Vehicle Simulation", unpublished report, Computer Science Department, Wayne State University (1983).

[HIMO'76] C.J. Nuttall and D.D. Randolph, "Mobility Analyses of Standard- and High-Mobility Tactical Support Vehicles (HIMO Study)", Mobility and Environmental System Laboratory, U.S. Army Engineer Waterways Experiment Station, Technical Report M-76-3 (February 1976).

[JURKAT'84] M.P. Jurkat, "Development of a Goal Oriented Vehicle Evaluation Support System", Davidson Laboratory Technical Memorandum SIT-DL-83-8-175 (January 1984).

[NOVAK'82] M.J. Novak, "Programs to Aid in Entry and Verification of Vehicular Data for the NATO Reference Mobility Model; Volume I - Operational Module, Volume II - Ride Dynamics Module, Volume III - Obstacle Crossing Module", Davidson Laboratory Report SIT-DL-82-9-2303 (September 1982).

[NRMM'79] P.H. Haley, M.P. Jurkat and P.M. Brady, Jr., "NATO Reference Mobility Model Users Guide", U.S. Army Tank-Automotive Command Report No. 12503 (September 1979), Volume I: Operational Modules, Volume II: Obstacle Module.

[NUTTALL'84] C.J. Nuttall, Private Communications (1984).

[RANDOLPH'83] D.D. Randolph, "A Methodology for Integrating Mobility Modeling in the Vehicle Acquisition Process", Proceedings of the 22nd U.S. Army Operations Research Symposium, Fort Lee, NJ (October 1983).

[TACV'8/78] D.D. Randolph, "Mobility Performance of Selected 1-1/4 to 5 Ton Cargo Trucks in the HIMO West Germany Study Area (TACV Excursion)", U.S. Army Engineer Waterways Experiment Station, Miscellaneous Paper M-78-9 (August 1978).

[TACV'11/78] D.D. Randolph, "Mobility Performance of 1/4 to 10 Ton Tactical Truck and Cargo Carriers in HIMO West Germany Study Area (TACV Study)", U.S. Army Waterways Experiment Station, Miscellaneous Paper M-78-15 (November 1978).

[VEHDYN'74] N.R. Murphy, Jr. and R.B. Ahlvin, "AMC-74 Vehicle Dynamics Module", U.S. Army Engineer Waterways Experiment Station, Technical Report M-76-1 (January 1976).

[VETDICT'83] EXTERNAL DATA DICTIONARY FOR THE VET SYSTEM (February 1983)

[WHEELS'72] Vehicle Mobility Assessment for Project Wheels Study Group (with Addenda), U.S. Army Tank-Automotive Command, Warren, Michigan and U.S. Army Engineer Waterways Experiment Station, Corps of Engineers, Vicksburg, Mississippi (September 1972).

END

DTIC

8-86